Moving from Conceptual Models to Community Index Models in the Evaluation and Selection of a Recommended Plan:

A Case Study in the Clear Creek Watershed (Texas)

Kelly A. Burks-Copes
US Army Engineer Research and Development Center (ERDC-EL)

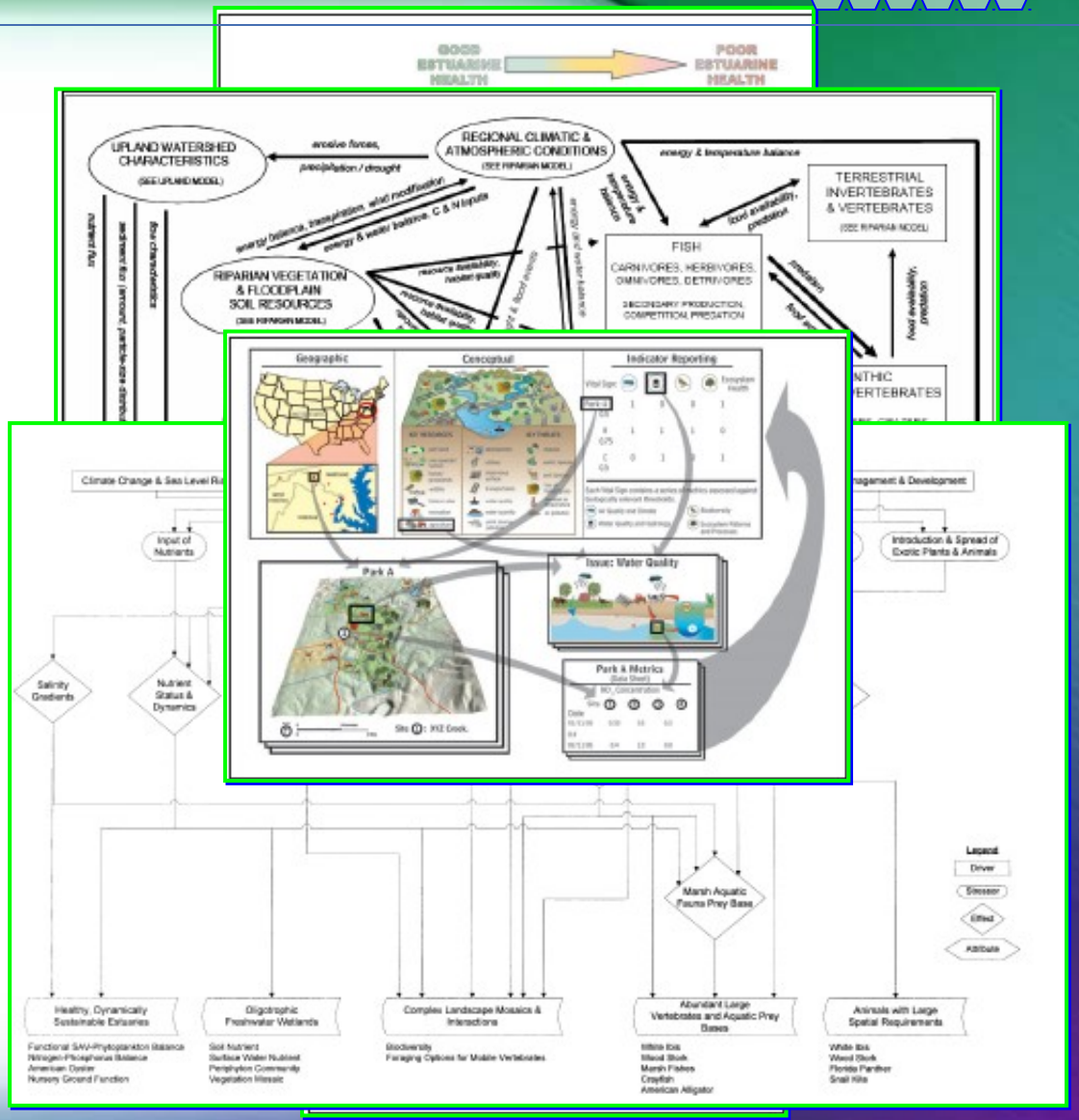
Andrea K. Catanzaro
USACE Galveston District

Antisa C. Webb
US Army Engineer Research and Development Center (ERDC-EL)

Conceptual Models

- Conceptual models are descriptions of the general functional relationships among essential components of an ecosystem (Fischenich, 2008)

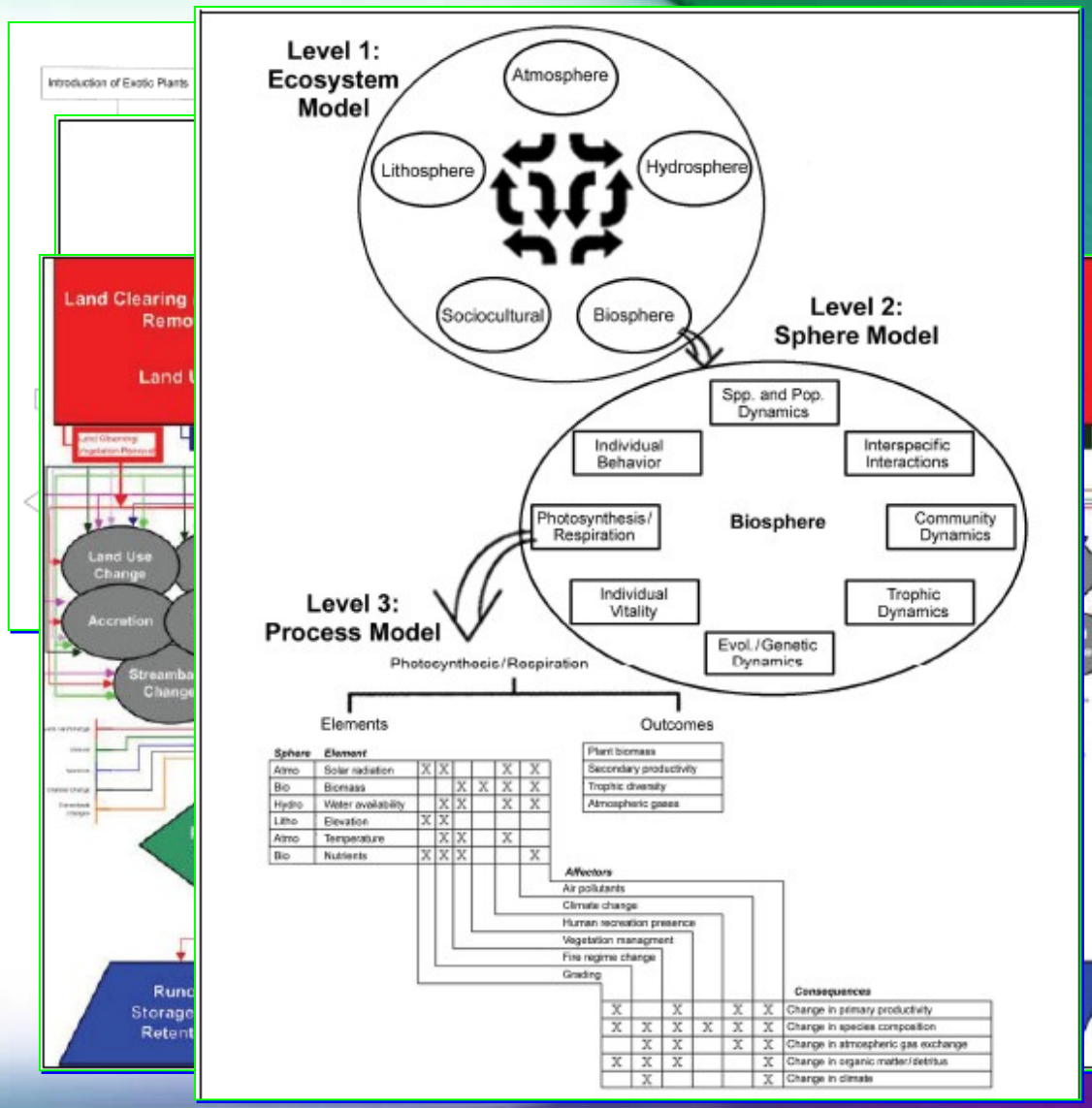
- They tell the story of "how the system works" and, in the case of eco-system restoration, how restoration actions aim to alter those processes or attributes for the betterment of the system.

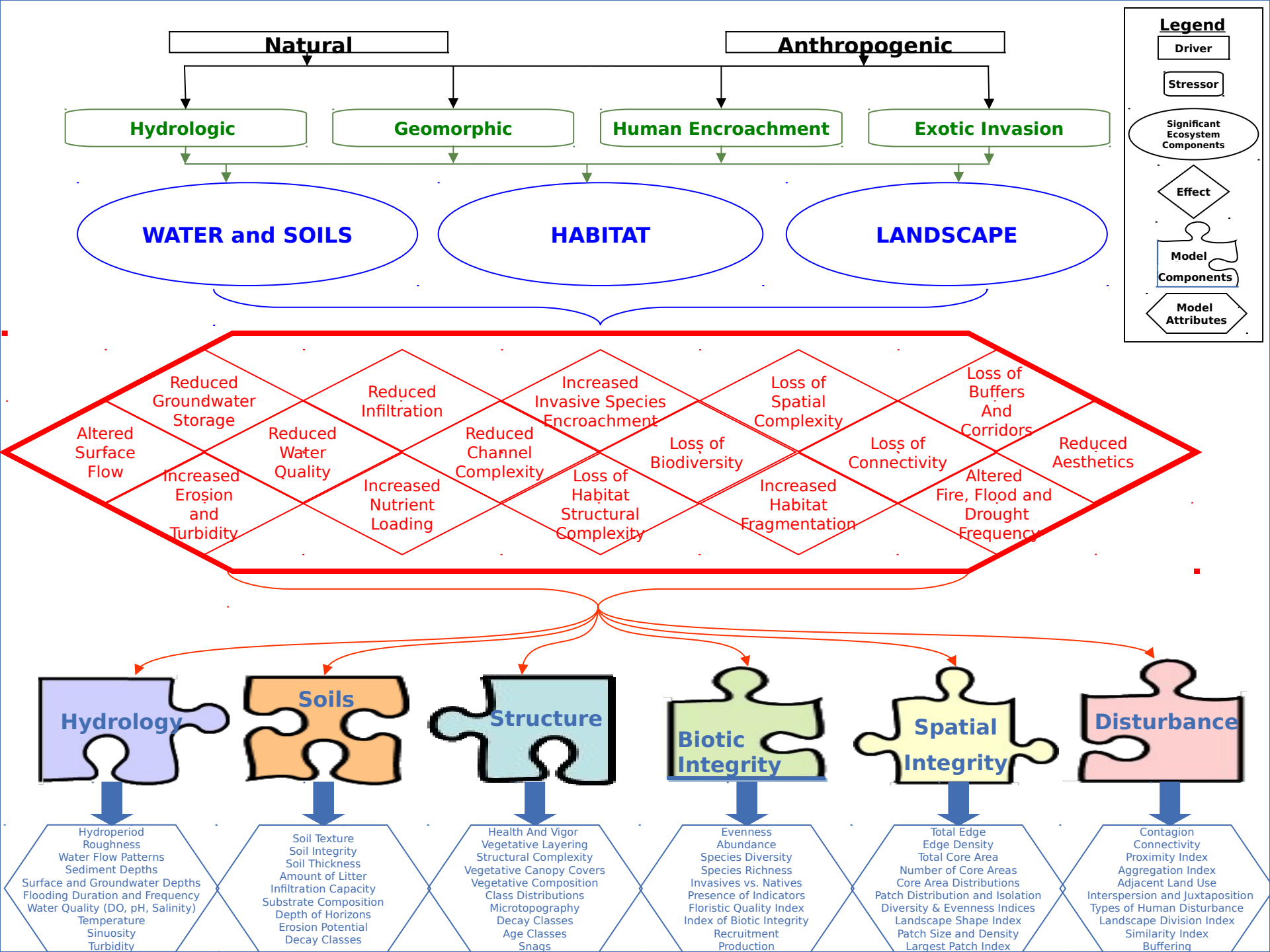


Graphics from Dennison et al. 2007; Fischenich 2008; Henderson and O'Neil 2007; *Wetlands Vol. 25(4) 2005;* and references therein

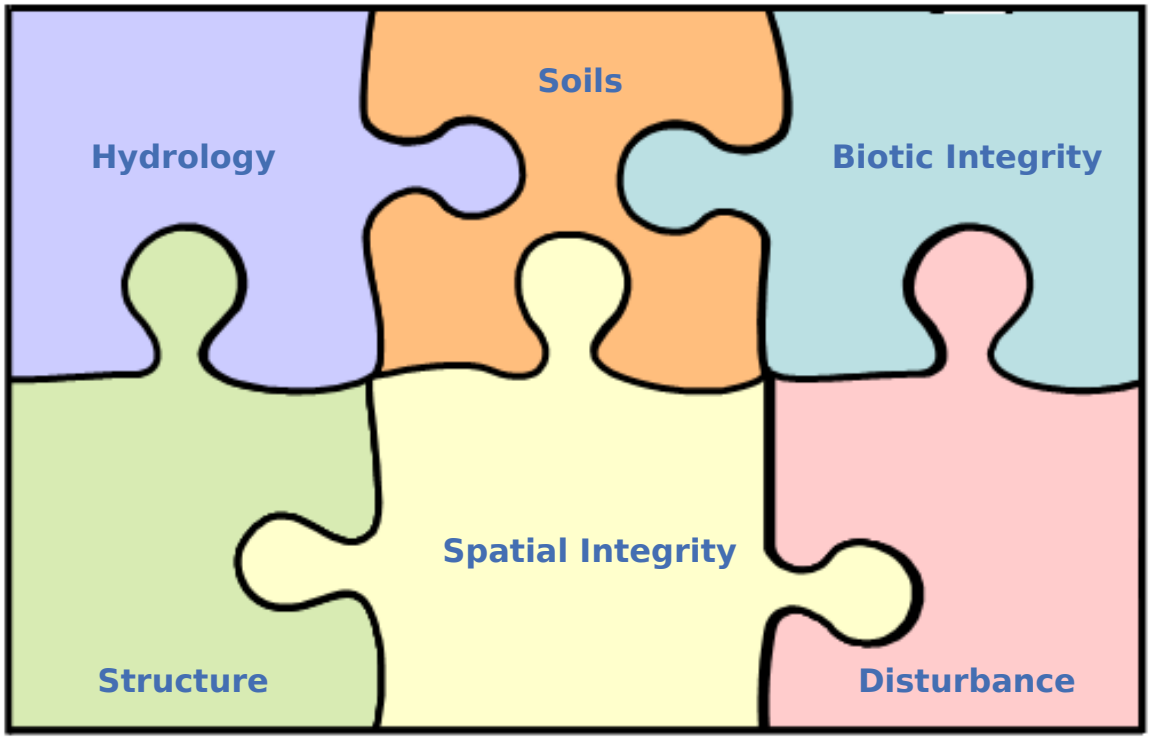
Conceptual Models Provide

- A synthesis of the current understanding of how a system works
- Help in understanding and diagnosing the underlying problem
- A basis for isolating cause and effect and simplifying complex systems
- A common framework or “mental picture” from which to develop alternatives
- A tool for making qualitative predictions of ecosystem response
- A way to flag potential thresholds, from which system responses may accelerate or follow potentially unexpected or divergent paths
- A means by which to outline further restoration, R&D, and computational efforts
- A supplement to numerical models for assessing project benefits and impacts
- A means of identifying appropriate monitoring indicators and metrics, and
- A basis for implementing adaptive management strategies



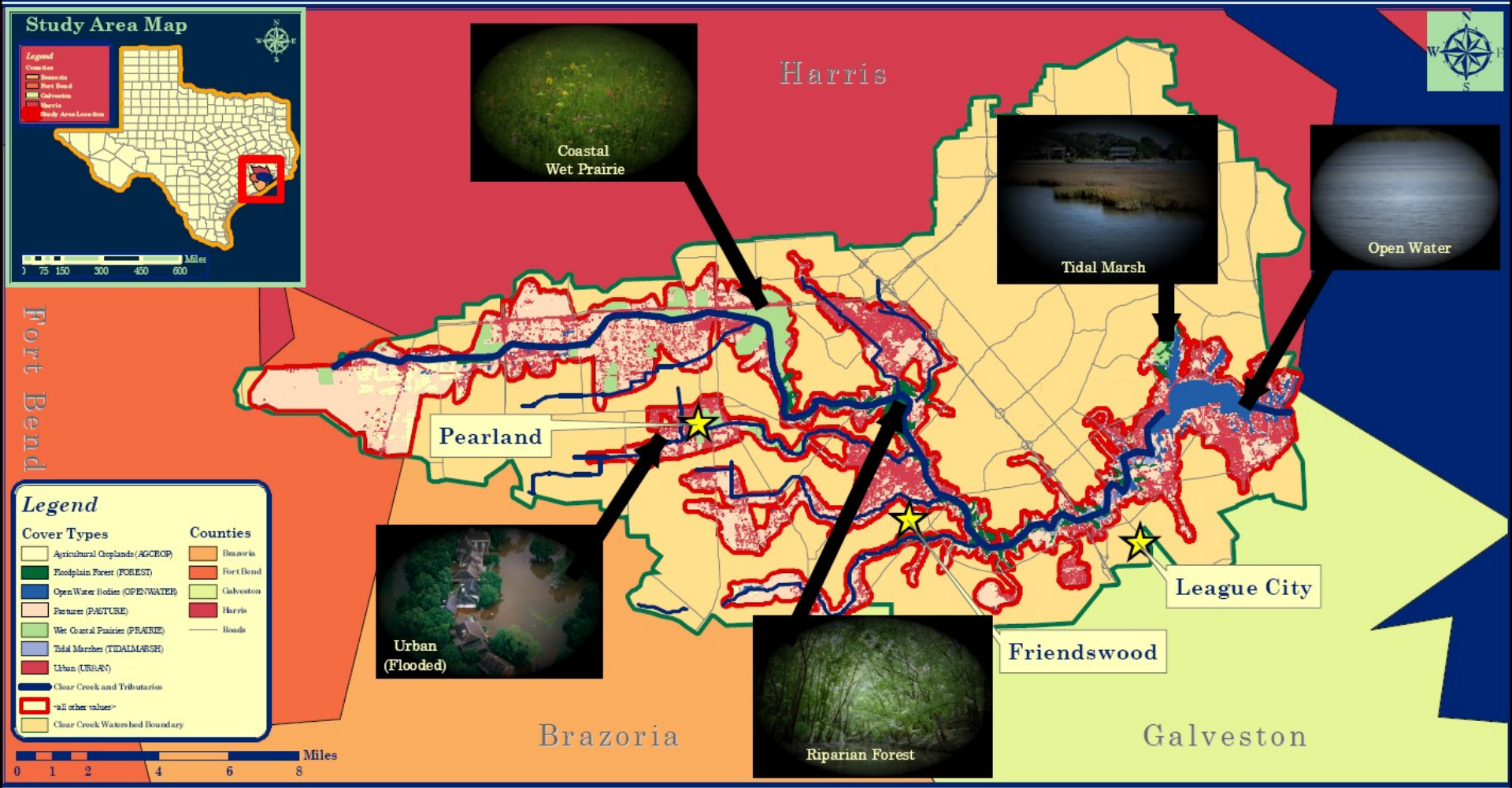

Natural
Anthropogenic
Hydrologic
Geomorphic
Human Encroachment
Exotic Invasion
WATER and SOILS
HABITAT
LANDSCAPE
Legend
Driver
Stressor
Significant Ecosystem Components
Effect
Model Components
Model Attributes
Altered Surface Flow
Reduced Groundwater Storage
Increased Erosion and Turbidity
Reduced Water Quality
Reduced Infiltration
Increased Nutrient Loading
Reduced Channel Complexity
Increased Invasive Species Encroachment
Loss of Habitat Structural Complexity
Loss of Biodiversity
Loss of Spatial Complexity
Increased Habitat Fragmentation
Loss of Connectivity
Loss of Buffers And Corridors
Altered Fire, Flood and Drought Frequency
Reduced Aesthetics
Hydrology
Soils
Structure
Biotic Integrity
Spatial Integrity
Disturbance
Hydroperiod
Roughness
Water Flow Patterns
Sediment Depths
Surface and Groundwater Depths
Flooding Duration and Frequency
Water Quality (DO, pH, Salinity)
Temperature
Sinuosity
Turbidity
Soil Texture
Soil Integrity
Soil Thickness
Amount of Litter
Infiltration Capacity
Substrate Composition
Depth of Horizons
Erosion Potential
Decay Classes
Health And Vigor
Vegetative Layering
Structural Complexity
Vegetative Canopy Covers
Vegetative Composition
Class Distributions
Microtopography
Decay Classes
Age Classes
Snags
Evenness
Abundance
Species Diversity
Species Richness
Invasives vs. Natives
Presence of Indicators
Floristic Quality Index
Index of Biotic Integrity
Recruitment
Production
Total Edge
Edge Density
Total Core Area
Number of Core Areas
Core Area Distributions
Patch Distribution and Isolation
Diversity & Evenness Indices
Landscape Shape Index
Patch Size and Density
Largest Patch Index
Contagion
Connectivity
Proximity Index
Aggregation Index
Adjacent Land Use
Interspersion and Juxtaposition
Types of Human Disturbance
Landscape Division Index
Similarity Index
Buffering

Model Components Combined to Form the Ecosystem Puzzle



Clear Creek Flood Risk Management Project

Baseline Cover Types in the Clear Creek Watershed

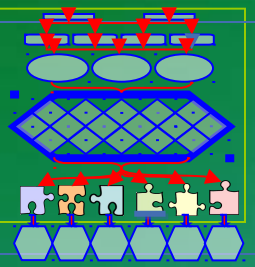


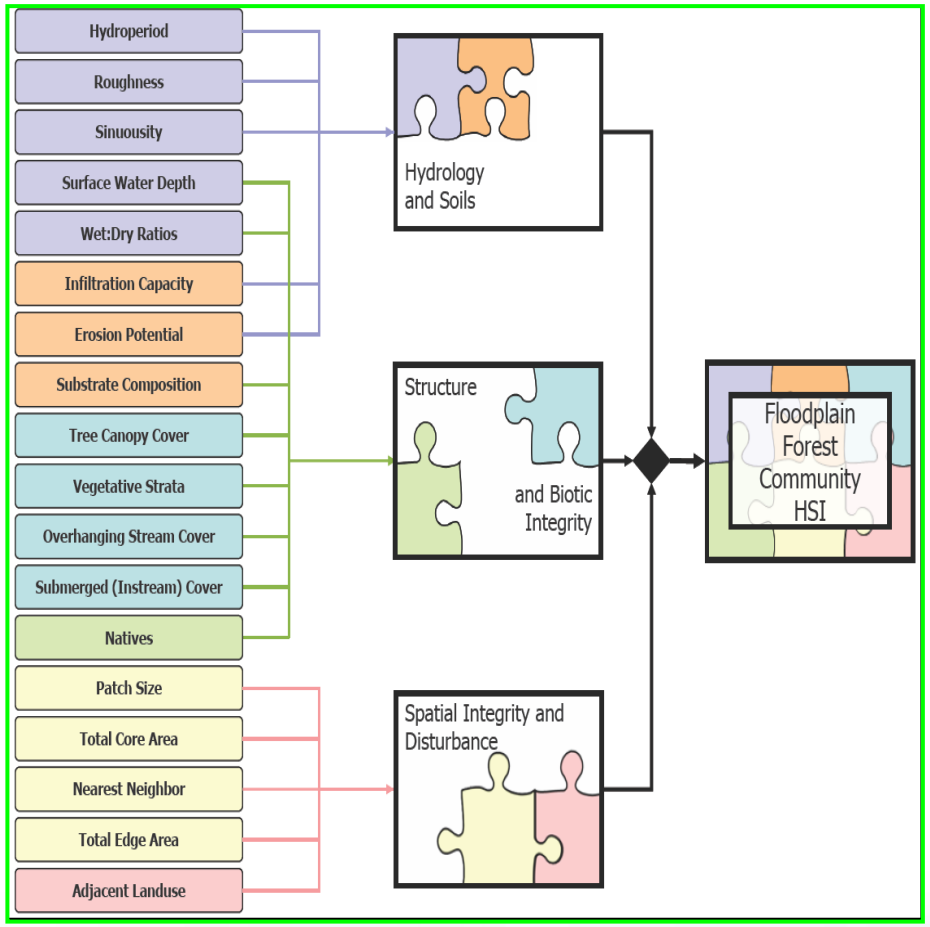
ERDC US Army Engineer Research and Development Center

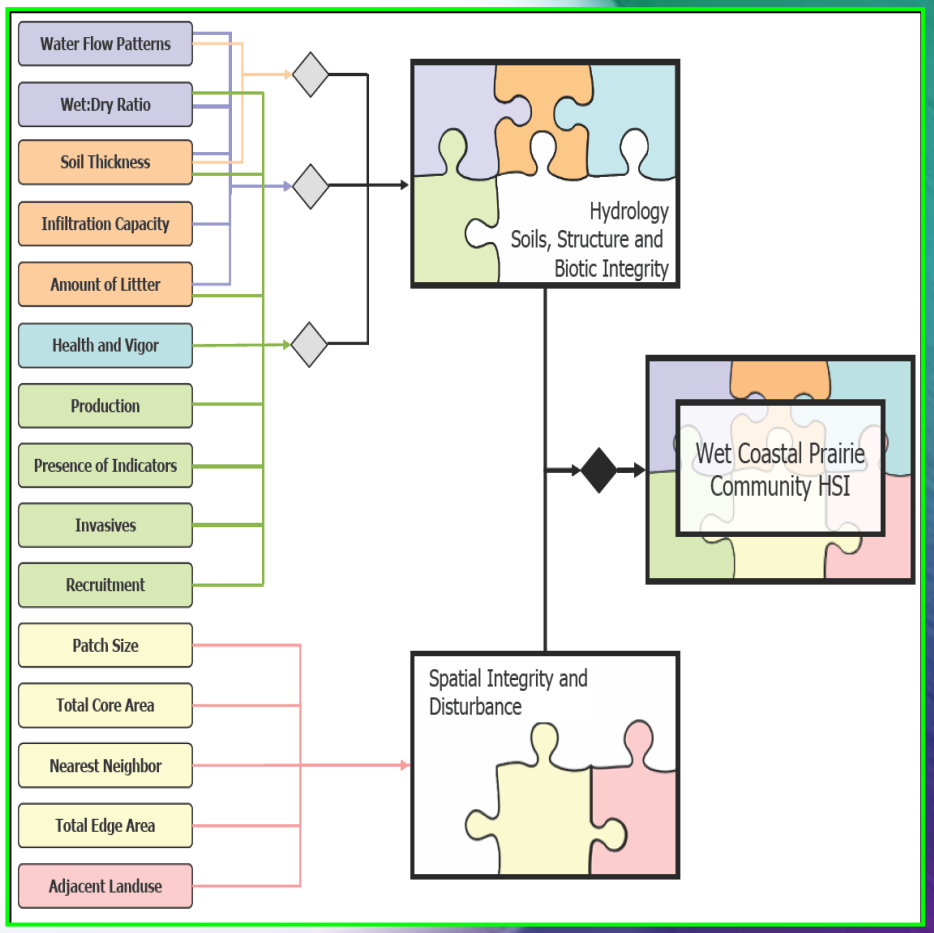
Map Developed by Kelly A. Burks-Copes in ERDC's Environmental Laboratory for the USACE Galveston District's Clear Creek Flood Risk Reduction Re-evaluation Project in April 2008

Projected Coordinate System: NAD_1983_StatePlane_Texas_South_Central_FIPS_4204_Feet
Projection: Lambert_Conformal_Conic
Geographic Coordinate System: GCS_North_American_1983
Datum: D_North_American_1983
Spheroid: GRS_1980

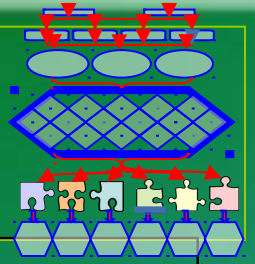
Modeling the Ecosystems





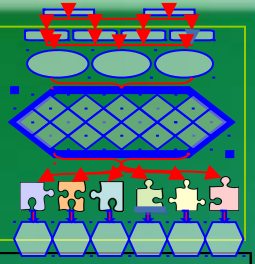


Clear Creek Floodplain Forest Model



Model Component	Variable Description	Variable Code	Formulas
Soils and Hydrology (HYDRO)	Hydroperiod	ALTERHYDRO	$\frac{V_{ALTERHYDRO} + V_{ROUGHNESS} + V_{IMPERVIOUS} + V_{SINUOSITY} + V_{EROSION}}{5}$
	Roughness	ROUGHNESS	
	Infiltration Capacity	IMPERVIOUS	
	Sinuosity	SINUOSITY	
	Erosion Potential	EROSION	
Structure and Biotic Integrity (BIOINTEG)	Natives	NATIVE	$\frac{\left[\frac{\left(V_{CANTREE} \times V_{NATIVE}\right)^{1/2} + V_{VEGSTRATA} + V_{AREAWETDRY}}{3}\right] + \left[V_{OVRHDCOV} \times V_{INSTRMCOV} \times \left(\frac{V_{VEGSTRATA} + V_{AREAWETDRY}}{2}\right)\right]^{1/3}}{2}$
	Tree Canopy Cover	CANTREE	
	Vegetative Strata	VEGSTRATA	
	Wet:Dry Ratios	AREAWETDRY	
	Overhanging Stream Cover	OVRHDCOV	
	Submerged (Instream) Cover	INSTRMCOV	
	Substrate Composition	SUBSTRATE	$\left\{\left(V_{PATCHSIZE} \times V_{CORE}\right)^{1/2} \times \left[\frac{V_{NEIGHBOR} + \left(V_{PATCHSIZE} \times V_{CORE}\right)^{1/2}}{2}\right]\right\}^{1/2}$
	Surface Water Depth	WATERDEPTH	
Spatial Integrity	Patch Size	PATCHSIZE	$\frac{V_{HYDRO} + V_{BIOINTEG} + V_{SPATIAL}}{3}$
	Total Core Area	CORE	

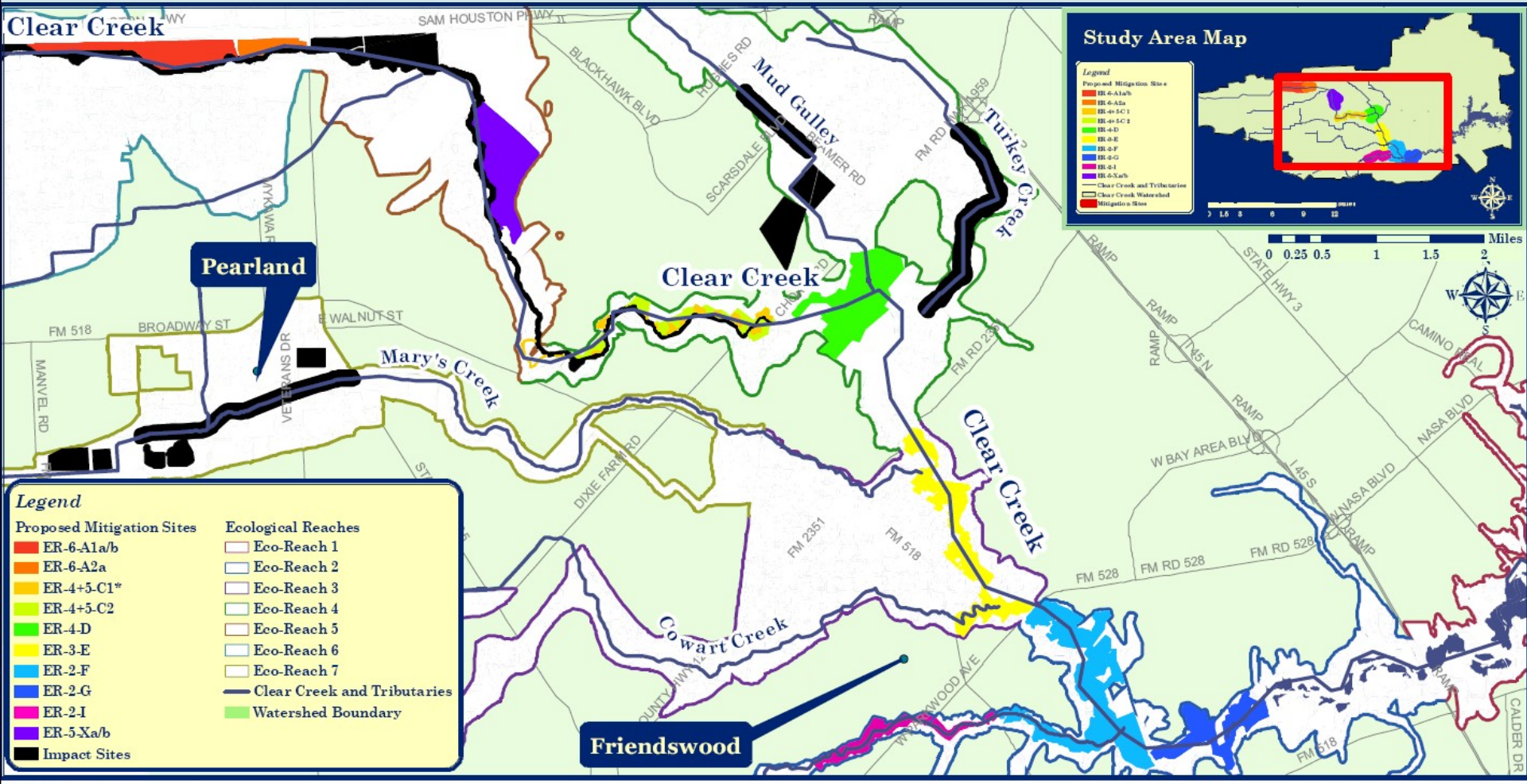
Clear Creek Wet Coastal Prairie Model



Model Component	Variable Description	Variable Code	Formulas
Soils (SOILSTAB)	Water Flow Patterns	WATERFLOW	$\frac{V_{WATERFLOW} + V_{SOILSURF}}{2}$
	Soil Thickness	SOILSURF	
Hydrology (HYDRO)	Wet:Dry Ratio	AREAWETDRY	$\frac{V_{AREAWETDRY} + V_{WATERFLOW} + V_{SOILSURF} + V_{INFILTRATE} + V_{AMTLITTER}}{5}$
	Water Flow Patterns	WATERFLOW	
	Soil Thickness	SOILSURF	
	Infiltration Capacity	INFILTRATE	
	Amount of Litter	AMTLITTER	
Structure and Biotic Integrity (BIOINTEG)	Wet:Dry Ratio	AREAWETDRY	$\frac{V_{AREAWETDRY} + V_{SOILSURF} + V_{FXNPPLANTS} + V_{STRESS} + V_{AMTLITTER} + V_{PRODUCTION} + V_{INVASIVES} + V_{RECRUIT}}{8}$
	Soil Thickness	SOILSURF	
	Presence of Indicators	FXNPLANTS	
	Health and Vigor	STRESS	
	Amount of Litter	AMTLITTER	
	Production	PRODUCTION	$\left\{\left(V_{PATCHSIZE} \times V_{CORE}\right)^{1/2} \times \left[\frac{V_{NEIGHBOR} + \left(V_{PATCHSIZE} \times V_{CORE}\right)^{1/2}}{2}\right]^{1/2}\right\}$
	Invasives	INVASIVES	
	Recruitment	RECRUIT	
Spatial Integrity and Disturbance	Patch Size	PATCHSIZE	$\frac{3 \times \left[\left(V_{SOILSTAB} \times V_{HYDRO} \times V_{BIOINTEG}\right)^{1/3} + V_{SPATIAL}\right]}{4}$
	Total Core Area	CORE	
	Nearest Neighbor	NEIGHBOR	

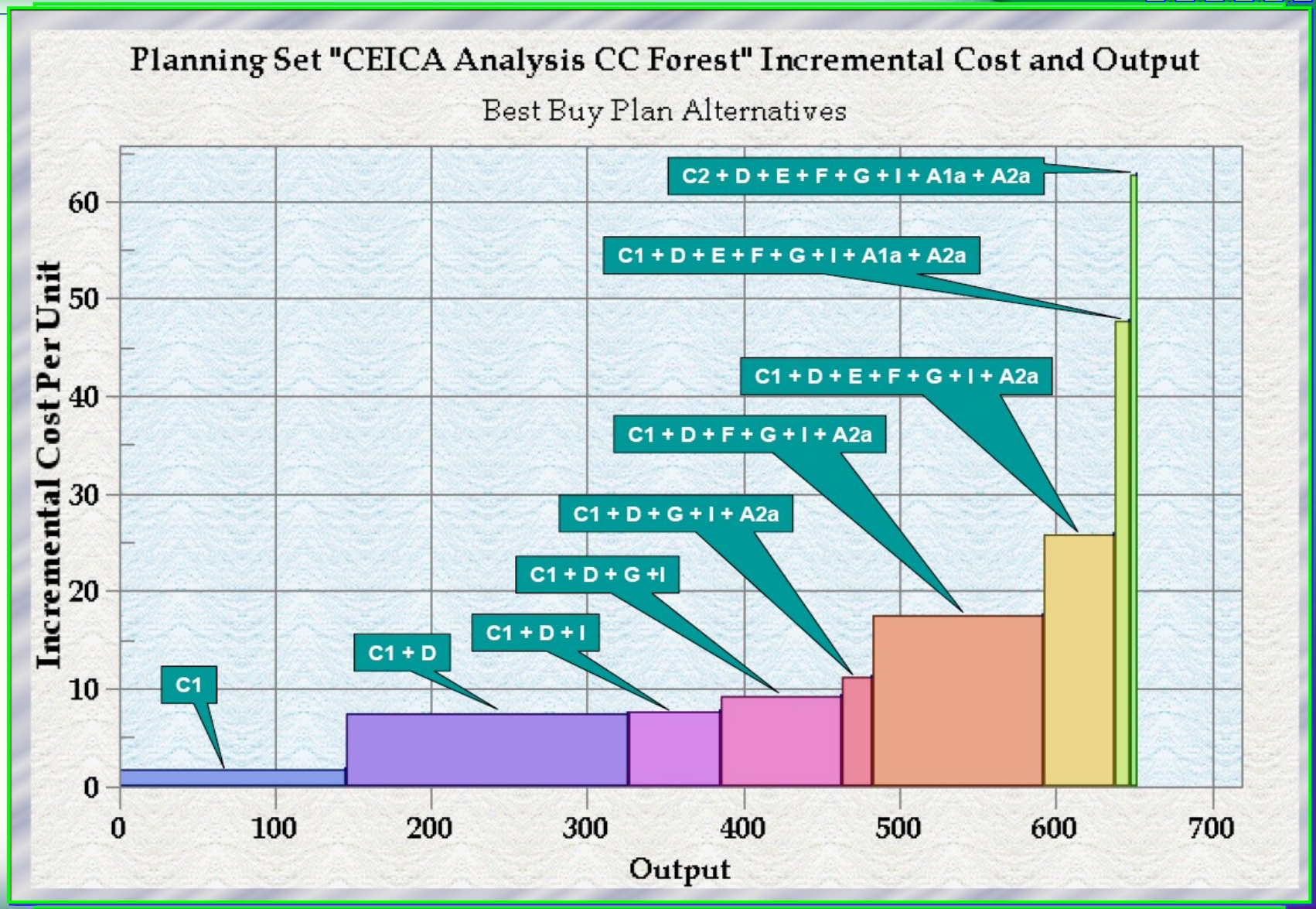
Impact and Mitigation Analysis

Location of Proposed Mitigation Sites for the Clear Creek Study



Map Developed by Kelly A Burke-Cogan in ERDC's Environmental Laboratory for the USACE Galveston District's Clear Creek Flood Risk Reduction Re-evaluation Project in April 2008

Moving Toward a Recommended Plan


Planning Set "CEICA Analysis CC Forest" Incremental Cost and Output
Best Buy Plan Alternatives
Incremental Cost Per Unit
Output
0
10
20
30
40
50
60
0
100
200
300
400
500
600
700
C1
C1 + D
C1 + D + I
C1 + D + G +I
C1 + D + G + I + A2a
C1 + D + F + G + I + A2a
C1 + D + E + F + G + I + A2a
C1 + D + E + F + G + I + A1a + A2a
C2 + D + E + F + G + I + A1a + A2a

Success!

- The approach served to inject valuable on-the-ground knowledge of experts and stakeholders into the strategic planning of the study's alternative designs and servd as a forum for the transparent assessment of impacts to the system's critical ecosystem functions and structure.

- The success of this coupling in the Clear Creek case study clearly demonstrates the efficacy of the approach and suggests other watershed-level studies can incorporate this technique into the modeling and assessment of critical land and water resources nationwide